

Astrobiology

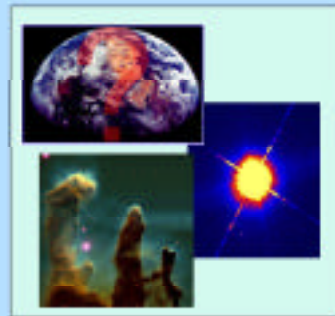
Presented by

Michael Meyer
and
Jerry Soffen

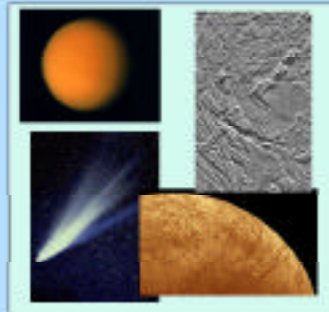
Astrobiology



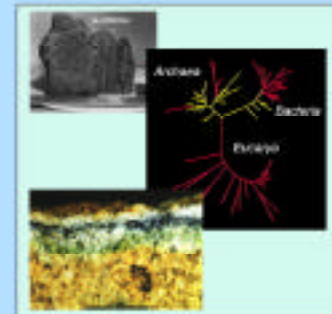
Is life universal?
How did life begin on Earth?
How did the Earth influence evolution?
What are the limits to life?
What is the destiny of life?



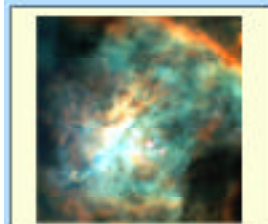
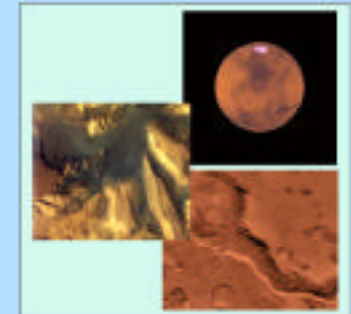
Origin



Evolution



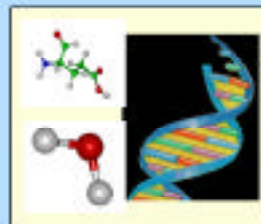
Destiny



Chemistry in the
Interstellar Medium



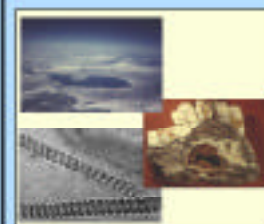
Stars and
Planetary
Systems



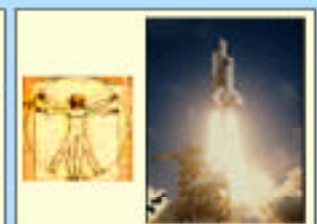
Prebiotic
Chemistry

?

Origin
of Life



Early
Life



Evolutionary
Biology

Human
Exploration



Astrobiology

Astrobiology is defined as the study of life in the universe; and the chemical and physical forces and adaptation that influence life's origins, evolution and destiny.

Astrobiology seeks to answer the question:

Is life a cosmic imperative?

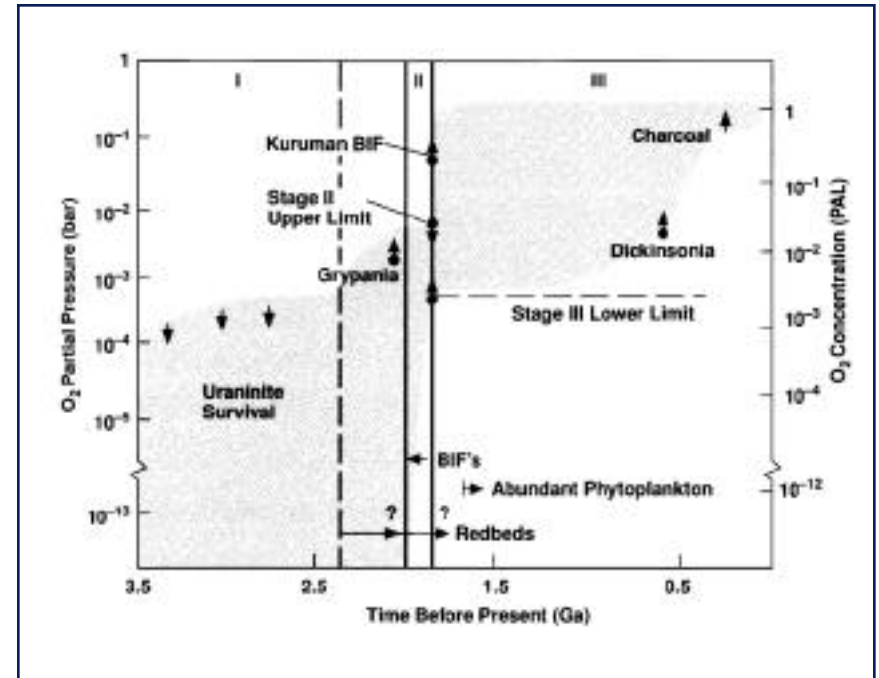


Example Questions

- How do habitable worlds form and how do they evolve?
- How did living systems emerge?
- How can other biospheres be recognized?
- How have the Earth and its biosphere influenced each other over time?
- How do rapid changes in the environment affect emergent ecosystem properties and their evolution?
- What is the potential for survival and biological evolution beyond the planet of origin?

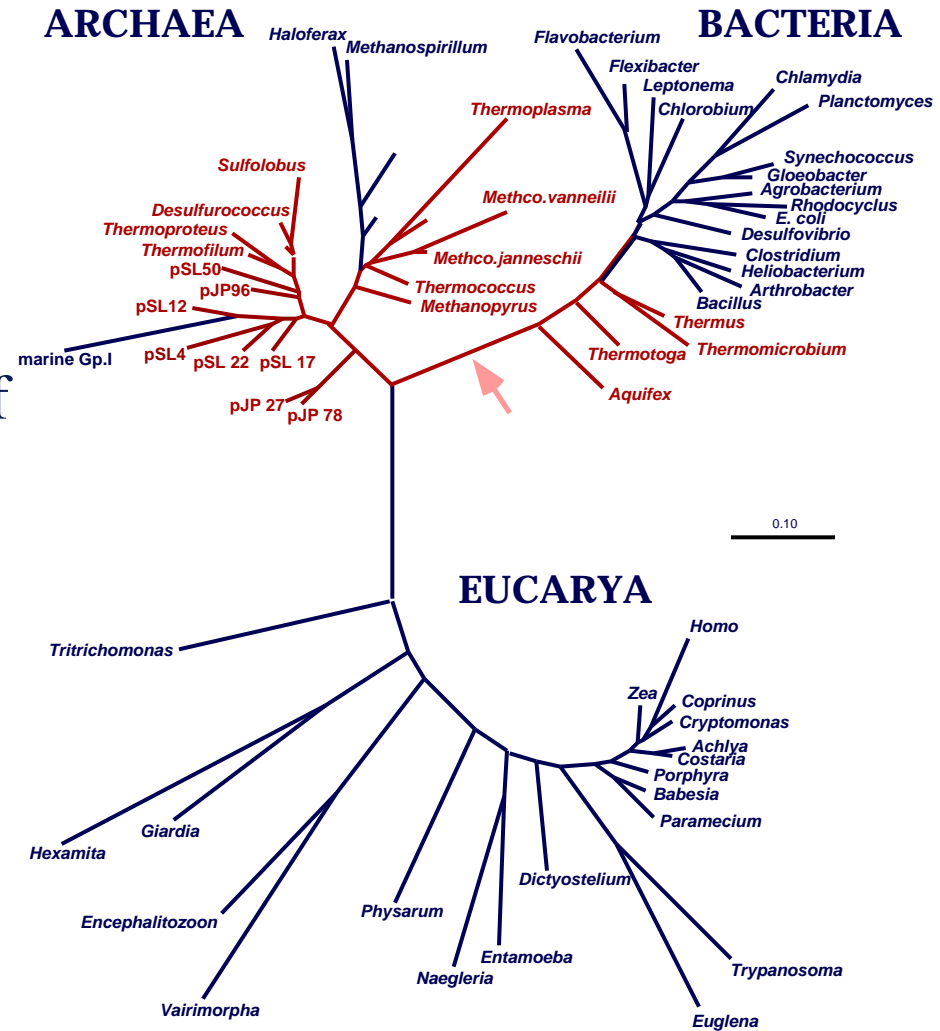
Evolution of Oxygen in the Biosphere

The evolution of oxygenated photosynthesis had a profound effect on life and planet Earth. The evolution of our biosphere is still a mystery.



Tree of Life

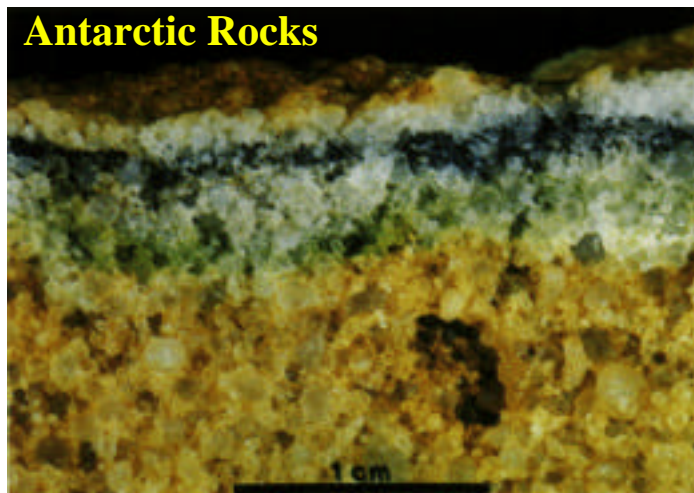
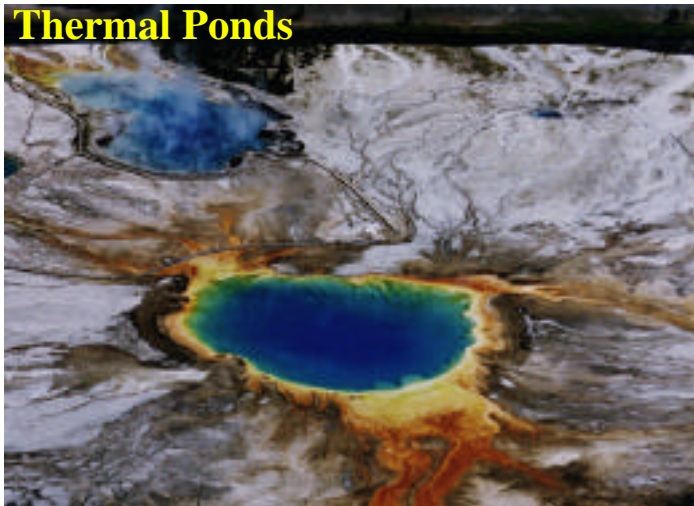
The phylogenetic record points to our last common ancestor and to the progress of evolution



Tree of Life based on SSU rRNA sequences

Extreme Environments

Extreme Environments – Sites of microbial diversity and analogs for life on other worlds





Astrobiology Elements

Exobiology

- NASA's Exobiology Program sponsors research centered on pathways leading to and from the origin of life. The approach is:
 - To trace the biogenic elements leading to the origin of life through both cosmochemistry and prebiotic evolution, and
 - To use the phylogenetic and geologic record to determine the nature of primitive microorganisms and the environment in which they evolved.
- This will be done to:
 - Understand the origin of life on Earth and,
 - To establish the basis upon which it will be possible to determine the potential for life elsewhere in the universe.



Astrobiology Elements (cont.)

Evolutionary Biology

- Evolution by natural selection is the central organizing paradigm in modern biology. The goal of NASA's Evolutionary Biology Program is to understand the physical and biological forces that affect biological evolution and the interaction of life with a planet's biosphere. NASA's compelling interests in this basic research are to understand:
 - How life is affected by basic planetary characteristics;
 - How life can become globally stable and persistent; the mechanisms and likelihood of major steps seen in terrestrial evolution (such as multicellularity) taking place once life arises;
 - What are the possible detectable signatures of extraterrestrial biospheres (in all stages of evolution);
 - What is the long-term stability of ecosystems that may be exported to support long-duration human exploration as life adapts to a novel environment.



Status

- Exobiology is included in Research Opportunities in Space Science with proposals due May 15.
- Evolutionary Biology draft NRA is being developed, to be released summer of 1998. Participation with two other science offices still under discussion.



NASA Astrobiology Institute (NAI)

- A nontraditional institute “without walls” whose members will propose and conduct interdisciplinary research and yet be geographically dispersed.
- The interactions between members will be enabled through use of the Next Generation Internet and similar technological innovations.
- The “virtual” nature will ensure that the Institute will have the breadth and talent to address a range of fundamental questions inherent in Astrobiology by linking together some of the finest minds in the Nation.
- Status
 - 53 proposals submitted, over 500 investigators involved
 - Selection of approximately 10 members to be announced in May
 - Institute director to be named in May



Publications

In 1997, eight research publications in *Science* or *Nature* and twelve letters, news, and comments

- **Habitable moons around extrasolar planets**
 - D. D. Williams, J. F. Kasting, & R. A. Wade
- **Oxidative acylation using thioacids**
 - R. Liu & L. E. Orgel
- **Enantiomeric excesses in meteoritic amino acids**
 - J. R. Cronin & S. Pizzarello
- **Low temperature carbonate concretions in the Martian meteorite ALH84001: Evidence from stable isotopes and mineralogy**
 - J. W. Valle, J. M. Eiler, C. M. Graham, E. K. Gibson, C. S. Romanek, & E. M. Stolper
- **Organic synthesis in experimental impact shocks**
 - C. P. McKay & W. J. Borucki
- **Continuous *in vitro* evolution of catalytic function**
 - M. C. Wright & G. F. Joyce
- **The early faint sun paradox: organic shielding of ultraviolet-labile greenhouse gases**
 - C. Sagan & C. Chyba
- **Sulfur and hydrogen anomalies in meteorite sulfonic acids**
 - G. W. Cooper, M. H. Theimens, T. L. Jackson & S. Chang

Workshops, Conferences, & Symposia

- The Blue Dot Workshop, June 1996
- Astrobiology Workshop, September 1996
- Evolutionary Biology Workshop, April 1997
- Origins of Life Gordon Conference, July 1997
- Astrobiology Institute Workshop, August 1997
- Molecular Phylogeny and Evolution, October 1997
- Tri-Annual Exobiology Symposium, November 1997
- American Society for Microbiology, May 1998
 - 5 Special Sessions on Astrobiology
- Life: From Local Origins to Global Persistence, June 1998
- Astrobiology Roadmap, July 1998
- How Small Can Life Be? NRC Workshop, Fall 1998
- Blue Dot Workshop II, October 1998





Astrobiology Roadmap

- Astrobiology Roadmap Workshop to be held July 20-22, 1998 at ARC
- Goals
 - Develop the research and development plan for Astrobiology for the 2000-2020 time frame, with focus on the first 5 years
 - Arrive at a consensus definition of NASA's Astrobiology program, including a set of fundamental science goals
 - Identify critical roles and interfaces played by current programs in accomplishing goals of Astrobiology
 - Define top level mission and technology requirements to achieve science goals
 - Ensure that all important communities and Agencies are represented in developing plan
 - Ensure that the Agency's Education and Public Outreach goals are incorporated into the Astrobiology program

Astrobiology Web Page

<http://astrobiology.arc.nasa.gov/>

